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MEMORANDUM FOR PRS (In-House/Contractor Publication)

FROM: PROI (STINFO)   08 Mar 2001

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2001-049**
Liu, C.T., "Predicting the Initial Crack Length in a Solid Propellant" (VuGraphs)

JANNAF 34th Structures & Mechanical Behavior Subcommittee Meeting   (Statement A)
(Cocoa Beach, FL, 26-30 Mar 2001) (Deadline: 22 Mar 2001)

Predicting the Initial Crack length in a Solid Propellant
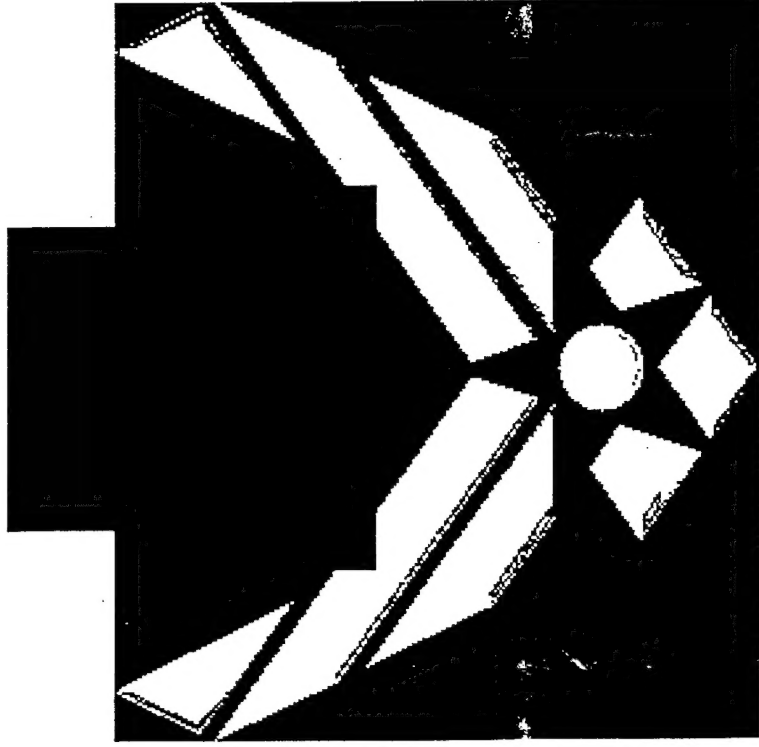
Dr. C. T. Liu

Air Force Research Laboratory

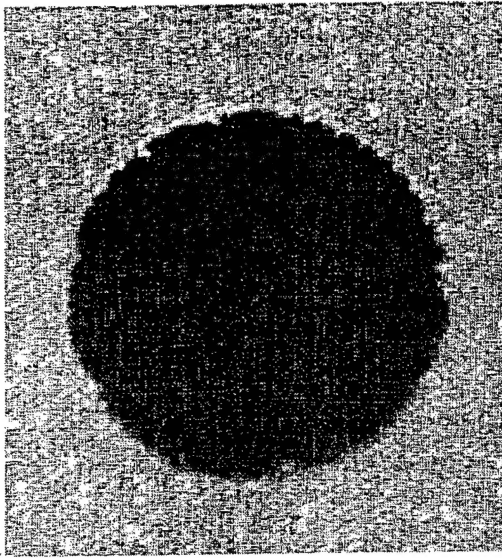Dr. Y. G. Kwon

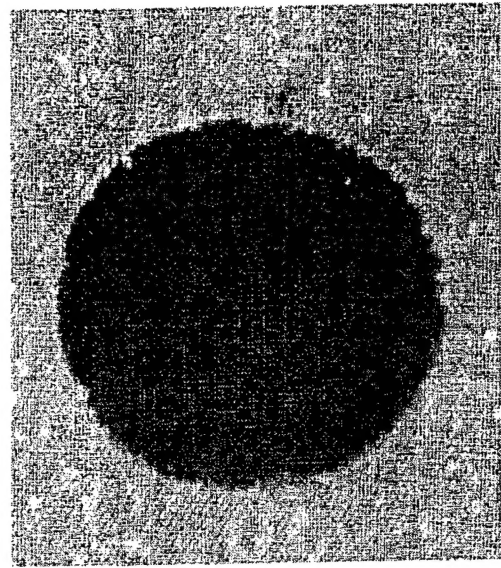Naval Postgraduate School

T. L. Hendrickson

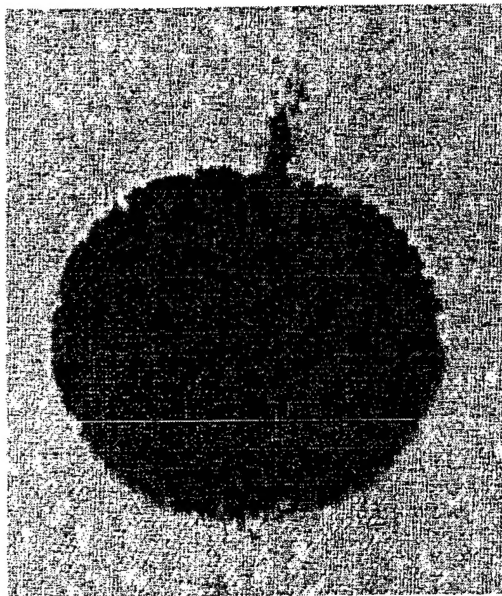Thiokol Co
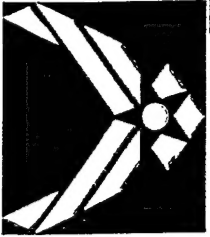
Objective
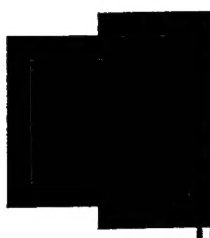
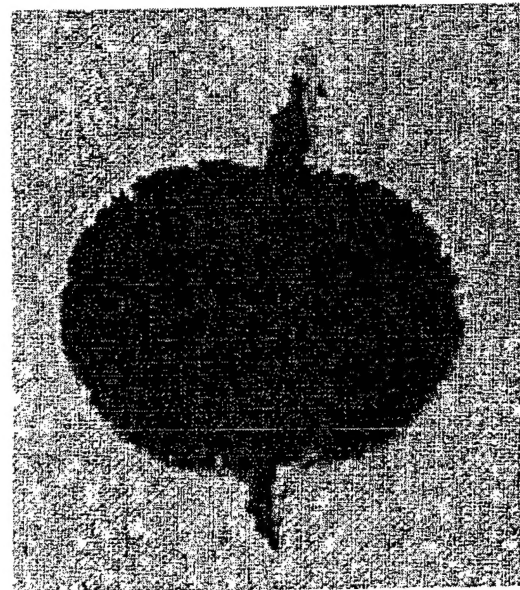- Predict the Initial Crack lengths in High Stress Regions in a Solid Propellant
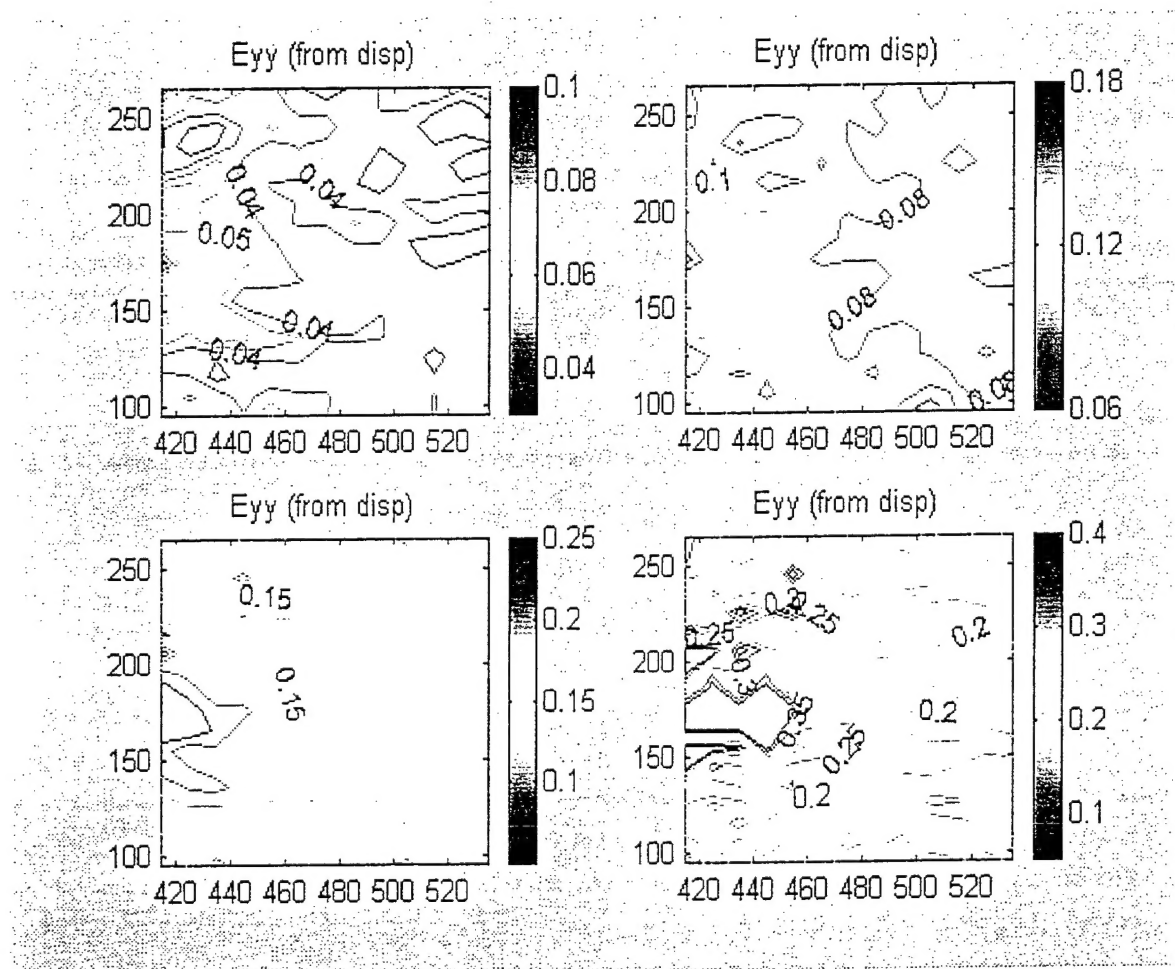
(a)

(b)

(c)

(d)

Figure   Formation of Initial Cracks at the Notch Tip: Increase in Applied Load from (a) to (d)

Contour Plots of Normal Strain in the Vertical Direction ($\mathcal{E}_{yy}$)
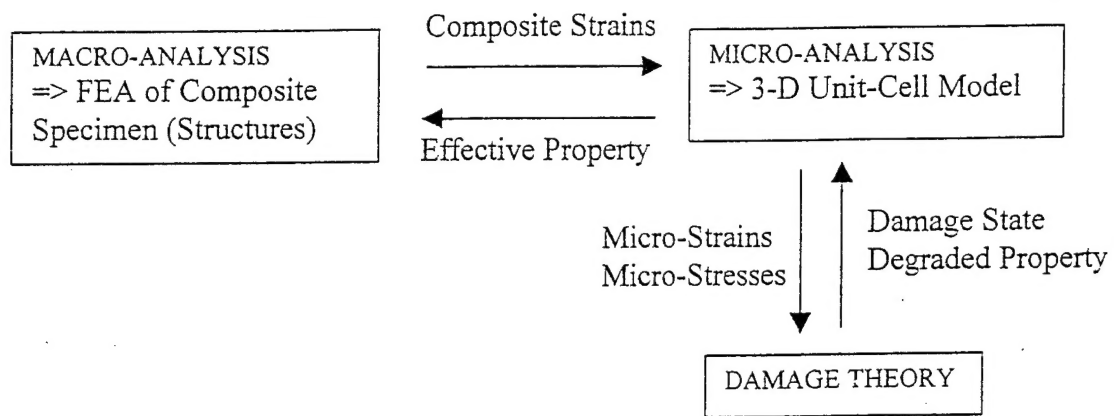## (Obtained from displacement fields)

Video 1

MACRO-ANALYSIS
=> FEA of Composite
Specimen (Structures)

Composite Strains

MICRO-ANALYSIS
=> 3-D Unit-Cell Model

Effective Property

Micro-Strains
Micro-Stresses

Damage State
Degraded Property

DAMAGE THEORY

Figure   Interaction between Micro-analysis and Macro-analysis

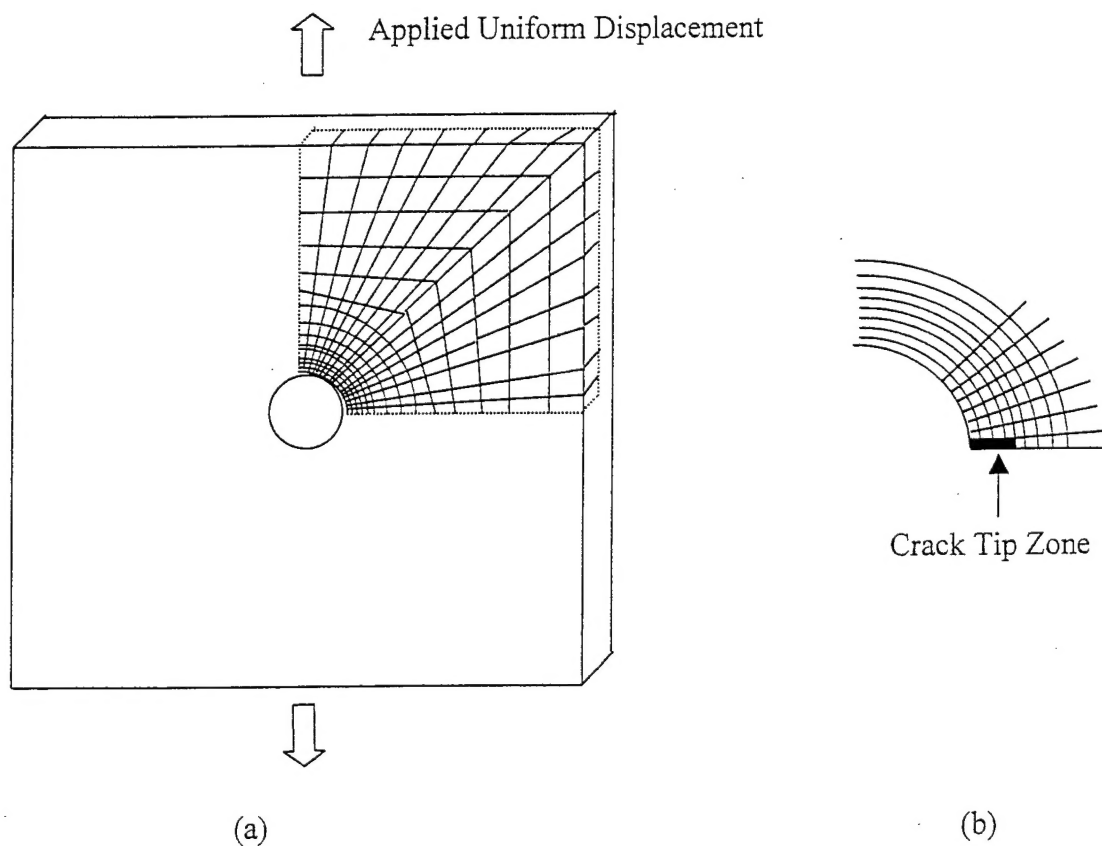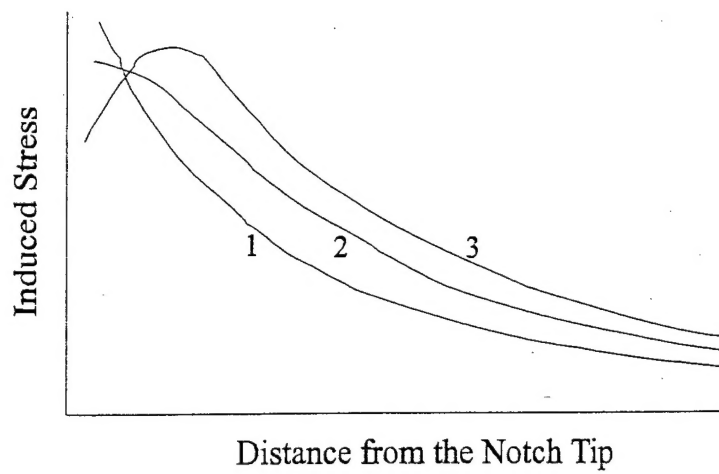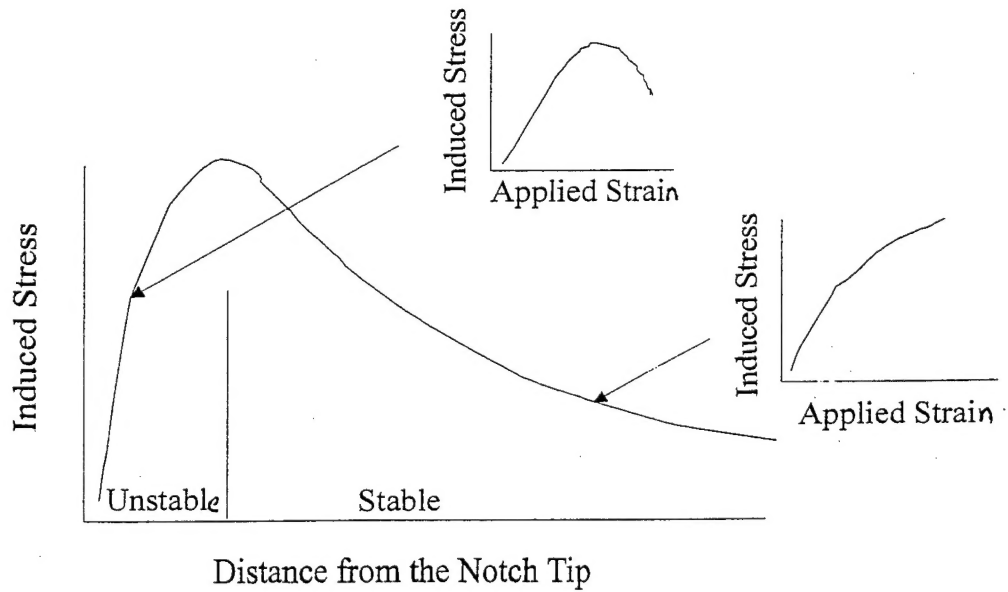Applied Uniform Displacement

Crack Tip Zone

(a)

(b)

Figure   Specimen Geometry and Finite Element Mesh: (a) Plate of 76.2 mm x 76.2 mm x 6.35

mm with a hole of radius 6.35 mm, (b) Enlarged View near the Notch Tip

Induced Stress

1   2   3

Distance from the Notch Tip

(a)

Induced Stress

Induced Stress

Applied Strain

Induced Stress

Applied Strain

Induced Stress

Unstable   Stable

Distance from the Notch Tip

(b)

Figure   Stress Distribution along the Minimum Section from the Notch Tip as a function of damage: (a) Damage Increases from Curve 1 to Curve 3, (b) Stable and Unstable Zones when Damage Saturates at the Notch Tip
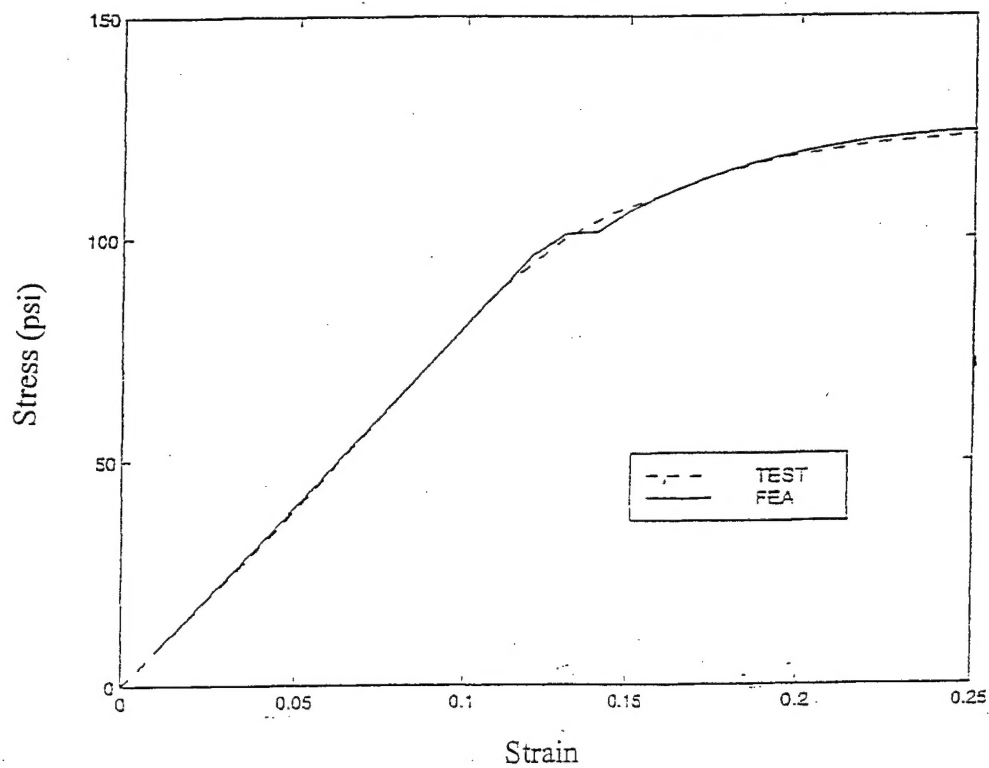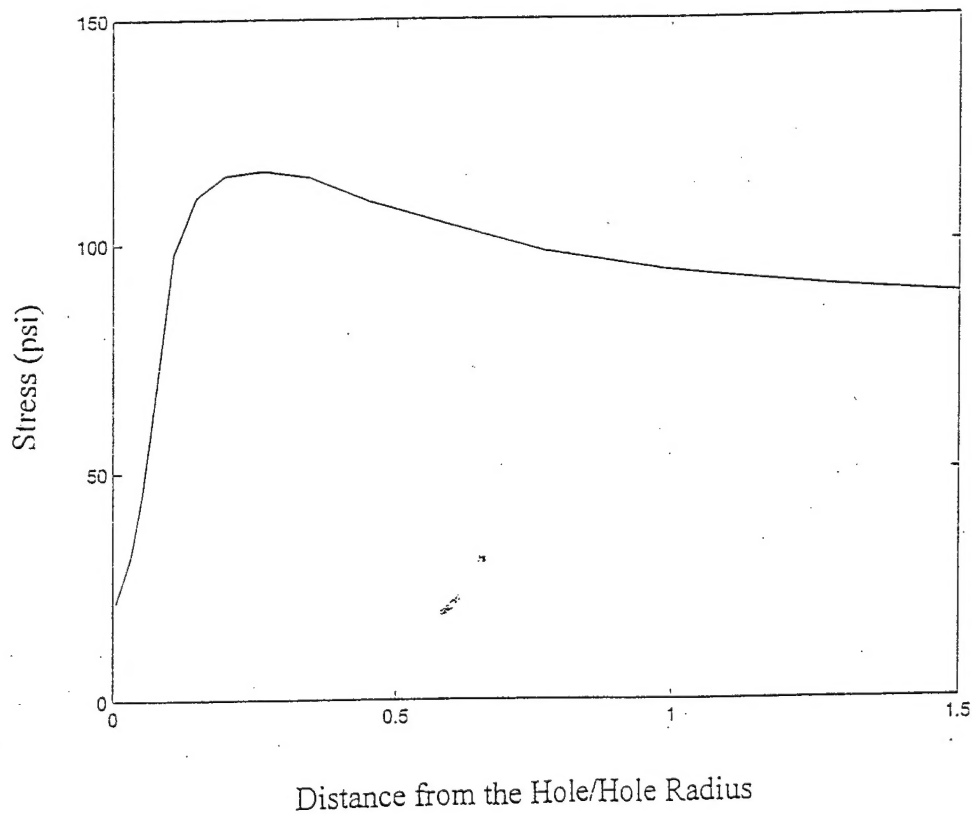
Figure   Stress-Strain Curves.

Distance from the Hole/Hole Radius

Figure   . Normal Stress Distribution as a Function of the Normalized
Distance from the Edge of the Hole (0.5 in Hole Diameter).

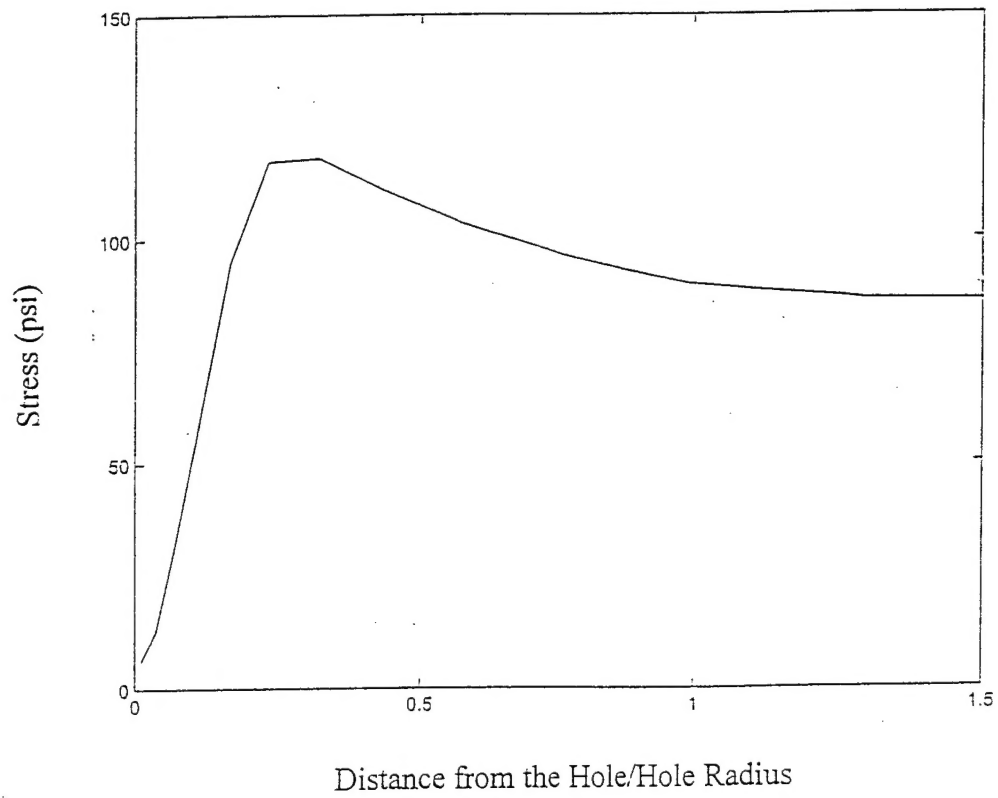Figure   Normal Stress Distribution as a Function of the Normalized
Distance from the Edge of the Hole (0.25 in Hole Diameter).

Conclusions

- A technique is (*was*) developed, based on a micro-macro approach and a stress instability criterion, to predict the initial crack length in a high stress region.

- The predicted and the measured average initial crack lengths are 0.0242 in. and 0.0307 in for D = 0.25 in. hole and 0.0489 in. and 0.0526 in for D = 0.5 in. hole.